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## THE STUDY OF MATHEMATICS AS AN AID TO GENERAL LOGICAL POWER.

BY LEONARD M. PASSANO.

In a paper read before a joint meeting of the New England Association of Mathematics Teachers and the Association of Teachers of Mathematics of the Middle States and Maryland,\* Mr. George G. Chambers analyzes the answers to a set of simple questions in logical reasoning made by forty-four "high school girls who had just completed a half year's work in plane geometry, . . . the first two books," and who had previously "studied algebra through simultaneous quadratics, spending on that five periods a week for one school year and two periods a week of one fourth of a school year, . . . followed by two periods a week for one fourth of a school year in constructive geometry." Before reading his paper Mr. Chambers obtained answers to the same set of questions from forty-eight persons present at the meeting.

It seemed to the present writer that a similar test made on other classes of students might prove of interest for purposes of comparison. It was also thought that some light might be thrown on the question whether the study of mathematical subjects strengthened the general "logical faculty." The writer, therefore, obtained answers to the set of questions from thirty-two freshmen and thirty-one sophomores of the Massachusetts Institute of Technology, at a time when the students had nearly completed the current year's work. Also, through the courtesy of Professor Sarah E. Smith, answers to the questions were obtained from twenty sophomore and twenty-one junior students of Mount Holyoke College, at about the time of completion of the year's work.† These respective groups had had, ap-

\* "A Study of the Reliability of Test Questions." See the *MATHEMATICS TEACHER* for March, 1915.

† The mathematics of Institute freshmen includes plane and solid analytic geometry and differential calculus; that of the sophomores, integral calculus and very elementary differential equations. The Mt. Holyoke sophomores had "had a half year of analytic geometry and a half year of calculus"; the juniors, "one and a half years of calculus."

proximately, the same amount of mathematical training. The technology students belonged to non-mathematical courses, and were by no means marked by exceptional mathematical ability; rather the reverse. One would suspect that the Mt. Holyoke students in question are a group of rather select individuals.

In the case of all classes of persons experimented upon, to quote Mr. Chambers, "particular care was taken to see that there was nothing said or done to indicate in the minds of the pupils that there was any connection between this test and their work in mathematics. No inquiries in regard to the meaning of the questions were answered." In the case of the Institute students the test was unannounced and unexpected, and Professor Smith gives the same assurance in respect to the Mt. Holyoke students. Mr. Chambers does not state how much time was allowed to his experimentees. With one or two exceptions, twenty to twenty-five minutes were found to be sufficient time for the college students, and in marking no distinction was made between those who returned the answers quickly and those who made use of the entire period of about fifty minutes.

The questions asked were the following:

I. Do you discover any defects in the following reasoning, and if so, explain why it is defective.

The sidewalk was wet this morning. Therefore it must have rained last night.

II. If all the inhabitants of the Rahib Islands have blue tattoo marks on their bodies, then which of the following statements would necessarily be true, which could not be true, and which might possibly be true?

1. All people who have blue tattoo marks on their bodies are inhabitants of the Rahib Islands.

2. Some inhabitants of the Rahib Islands do not have blue tattoo marks on their bodies.

3. No people with blue tattoo marks on their bodies live anywhere except on the Rahib Islands.

4. Some of the inhabitants of the Rahib Islands have blue tattoo marks on their bodies.

III. A certain club wishes to select the evening for its regular weekly meeting which would be most satisfactory to its members. Accordingly the secretary wrote to each member, asking what evening would be most satisfactory.

Can you suggest another question which would have been better for the secretary to have asked?

IV. If a photographic plate be exposed to X-rays, and then developed, black marks will be found upon it.

1. If upon developing a photographic plate you should find black marks upon it what would you conclude?

2. Also if you should not find black marks upon it what would you conclude?

V. If John agrees to join the football team provided Charles joins it, but Charles decides not to join it, what follows about John? If John joins, but Charles does not join, is John breaking his agreement?

The writer will not enter into any defence or criticism of the above questions; in marking them he followed, as exactly as possible, the plan outlined in Mr. Chambers's paper, to which reference has been made.\*

In the following tables and plates the high-school girls are represented by the letter *S*, the group of teachers by *T*, Institute freshmen by *I*<sub>1</sub>, Institute sophomores by *I*<sub>2</sub>, Mt. Holyoke sophomores by *H*<sub>1</sub>, Mt. Holyoke juniors by *H*<sub>2</sub>.

TABLE I.

Points Obtainable.	Number Obtaining.						Percentage Obtaining.					
	<i>S.</i>	<i>T.</i>	<i>H</i> <sub>1</sub> .	<i>H</i> <sub>2</sub> .	<i>I</i> <sub>1</sub> .	<i>I</i> <sub>2</sub> .	<i>S.</i>	<i>T.</i>	<i>H</i> <sub>1</sub> .	<i>H</i> <sub>2</sub> .	<i>I</i> <sub>1</sub> .	<i>I</i> <sub>2</sub> .
9		18	3	7	6	7		38	15	33	18	22
8	1	12	7	7	10	11	2	25	35	33	30	34
7	3	7	6	4	3	6	7	15	30	19	9	19
6	11	6	3	1	8	3	25	13	15	5	24	9
5	11	2		1	4	3	25	4		5	12	9
4	5	3	1		1	2	11	6	5		3	6
3	10						23					
2	2			1	1		4			5	3	
1	1						2					

TABLE II.

Points.	Percentage Obtaining.					
	<i>S.</i>	<i>T.</i>	<i>H</i> <sub>1</sub> .	<i>H</i> <sub>2</sub> .	<i>I</i> <sub>1</sub> .	<i>I</i> <sub>2</sub> .
7 or over.....	9	78	80	85	57	75
8 or over.....	2	63	50	66	48	56

An examination of the graphs seems to furnish some interesting information. The high-school girls (*S*) and the teachers (*T*), Fig. 1, give such results as one might expect; the former an approximate probability curve and the latter a curve begin-

\* The present writer marked the Mt. Holyoke as well as the Institute papers, so that the same "personal equation" appears throughout.

ning farther to the right and rising to a maximum at nine points. The writer confesses to some surprise that no more than 38 per cent. of the teachers answered all nine questions correctly. The

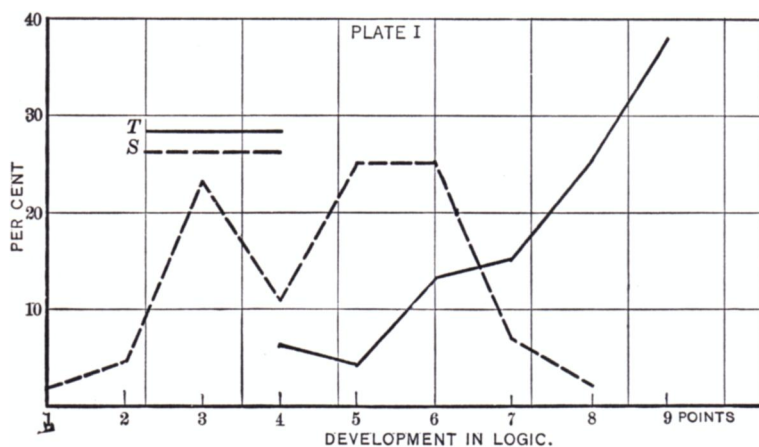


FIG. 1. Development in Logic.

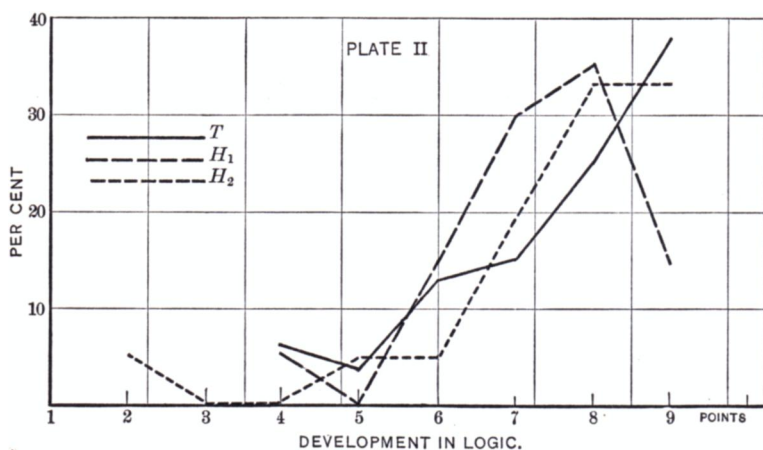


FIG. 2. Development in Logic.

teachers' curve may be looked upon as a standard ; it is repeated, for purposes of comparison, in Figs. 2 and 3. That the graphs begin farther to the right as one passes to the higher grades is due, doubtless, to the weeding out of weaker students.

Fig. 2 compares the sophomore ( $H_1$ ) and junior ( $H_2$ ) students of Mt. Holyoke College, and shows, on the whole, an advance with longer training. Fig. 3 makes the same comparison, with like conclusions, for the two groups of Technology

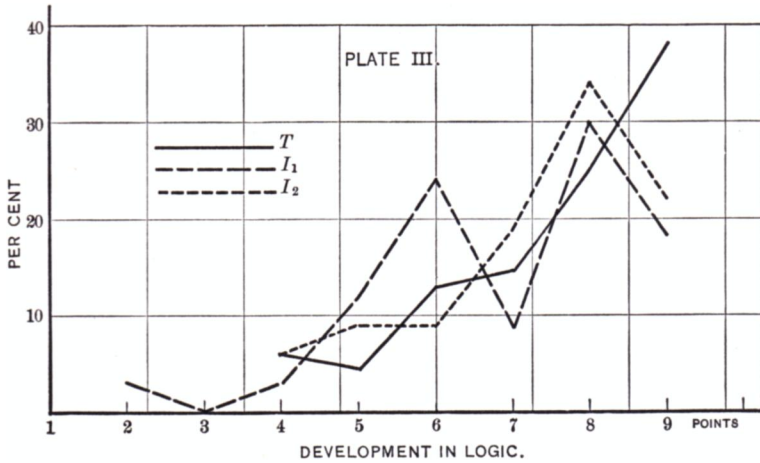


FIG. 3. Development in Logic.

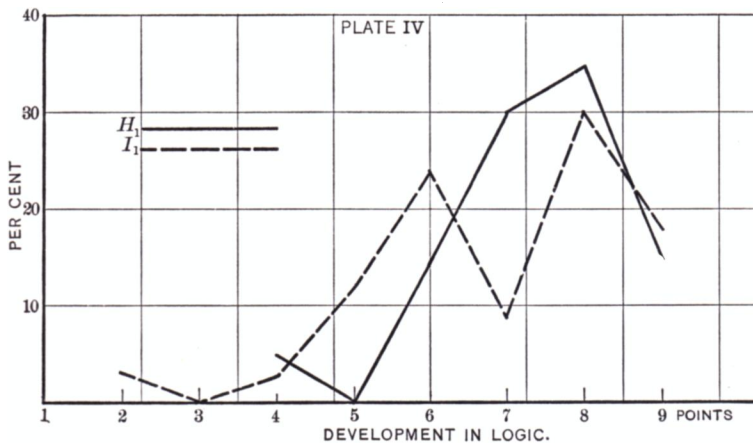


FIG. 4. Development in Logic.

students ( $I_1$  and  $I_2$ ). Figs. 4 and 5 make respectively a comparison between lower classmen ( $H_1$  and  $I_1$ ) and upper classmen ( $H_2$  and  $I_2$ ) of the two colleges.

As a further test, after an interval of about three days, the four groups of college students were asked to write the *questions* which had been asked in the preceding test. It was hoped

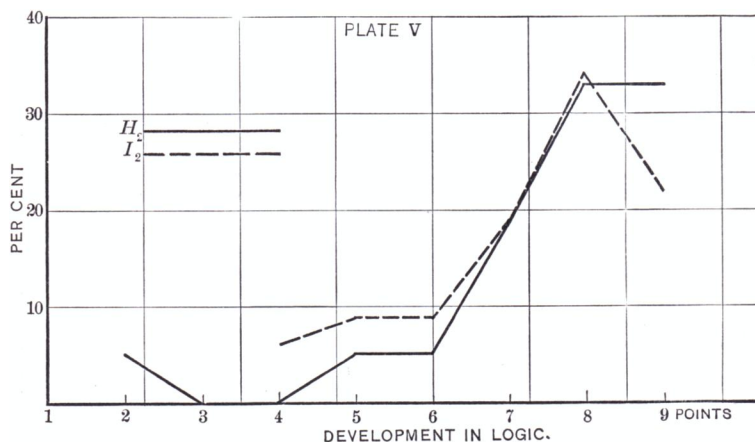


FIG. 5. Development in Logic.

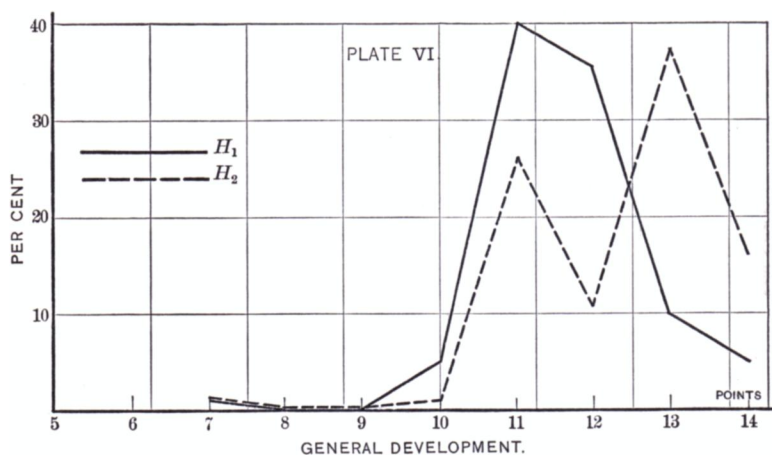


FIG. 6. General Development.

in this way to obtain data by which to evaluate the memory of the students for essentials. For this purpose each of the questions received one mark, making a total of five. In question II, a student remembering the primary statement and any one

of the sub-statements or conclusions received full credit for the question. Number IV. was similarly treated. There were thus fourteen points in all (9 logic ; 5 memory) to measure total mental development—if it may be permitted to call it so. The

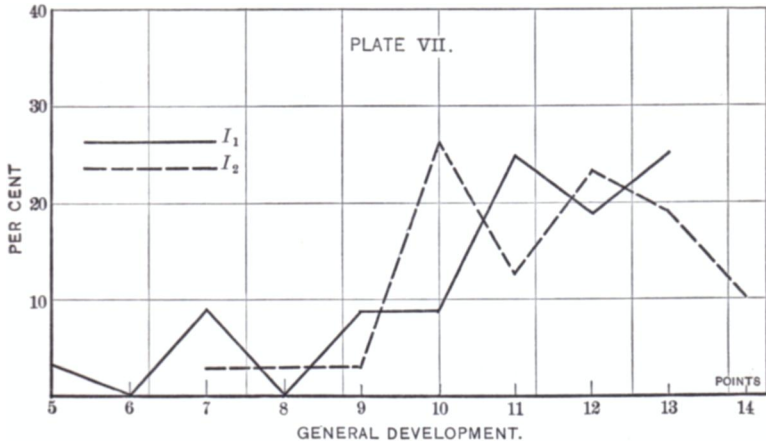


FIG. 7. General Development.

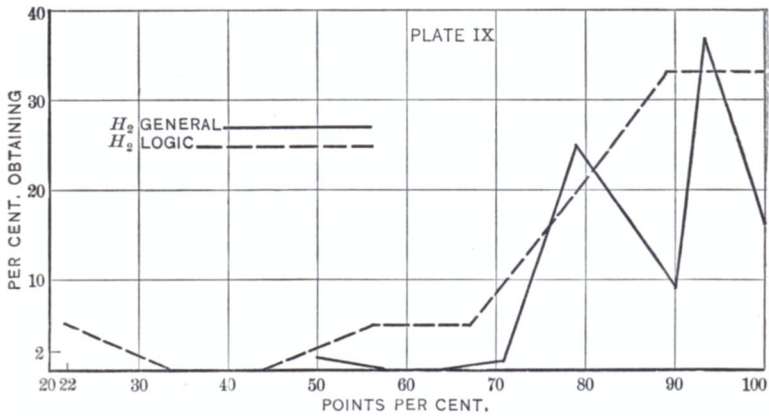


FIG. 8.

following tables, III. and IV., and figures 6 to 11 give the results obtained. Figs. 6 and 7 give the results of Table III graphically. Figs. 8, 9, 10 and 11 compare, for each group of students, the logical development with the general development, the horizontal axis giving percentages instead of points.



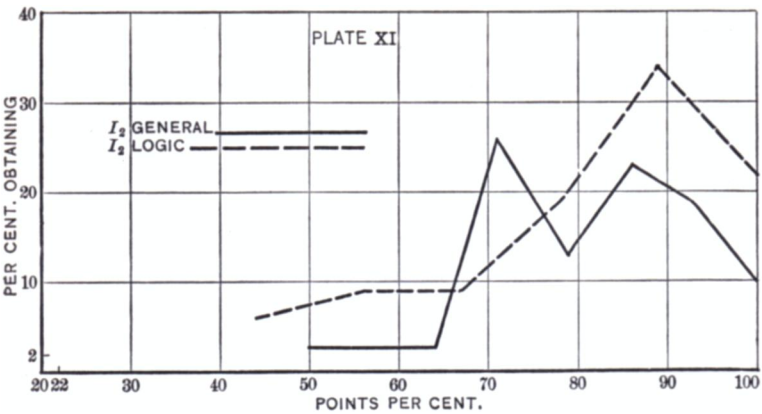


FIG. 11.

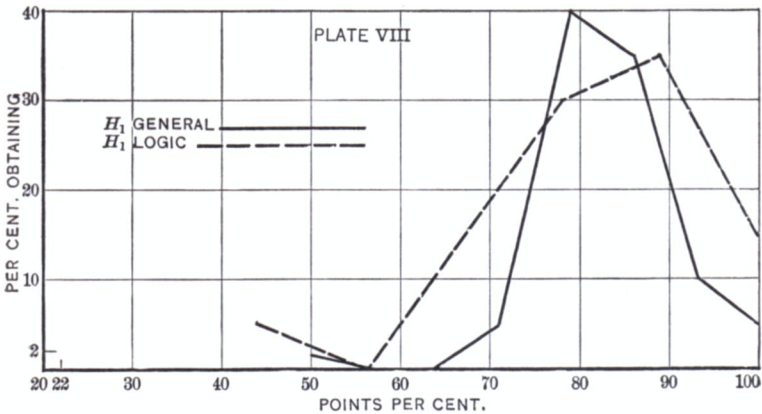


FIG. 9.

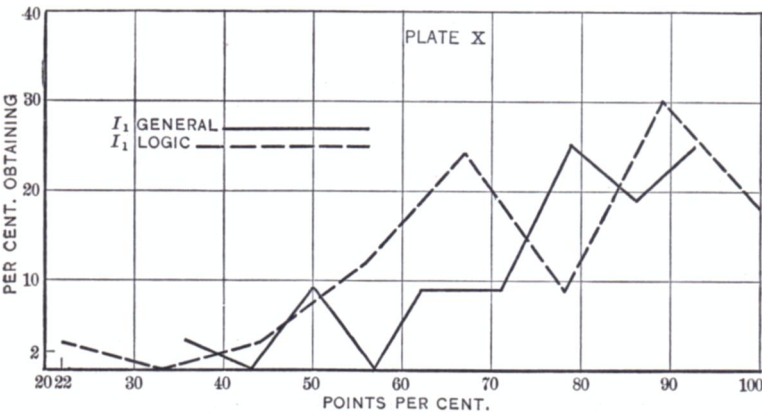


FIG. 10.

The writer would not too boldly draw conclusions from the few data of the above tests, but he believes that it may be asserted that evidence is here presented that training in mathematical studies does to some degree train the general logical faculty as well as memory in general, and that the increase in

TABLE III.

Points.	Percentage Obtaining.			
	$H_1$ .	$H_2$ .	$L_1$ .	$L_2$ .
14	5	16		10
13	10	37	25	16
12	35	11	19	23
11	40	26	25	13
10	5	1	9	26
9			9	3
8				3
7	1	1	9	3
6				
5			3	

TABLE IV.

Points.	Percentage Obtaining.			
	$H_1$ .	$H_2$ .	$L_1$ .	$L_2$ .
12 or over.....	50	64	44	52
13 or over.....	15	53	25	29

logical development is greater than the increase in general development.

Mr. Chambers, in his paper, calls attention to two "unethical" high-school girls, one of whom, in reference to question V., said that John should not be considered as breaking his agreement "because the matter was not of such importance that to change his mind could be called breaking his agreement." The other said that John breaks his agreement "provided the agreement was written and signed by both parties"; otherwise John "is eligible to break his word." It may be remarked that two of the Institute of Technology freshmen held the latter unethical view, but none of the sophomores and none of the Mount Holyoke students. It is pleasing to draw the conclusion that both the technical school and the woman's college tend to the improvement of morals.

In conclusion it may be remarked, with reference to question III. in the memory test, that to all of the young men the club was simply a club. To one young woman it was a "man's" club; to two a "woman's" club; and to a fourth a "prominent" club. Finally, one young woman, intolerant of the slowness of the post, asserts that the secretary "called up" the different members of the club!

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